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1300 Errors of Refraction.

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THE MODERN EYE

With an Analysis of 1300 Errors of Refraction.

By W. F. SOUTHARD, A. M., M. D. (Harv.)

(Read before the San Francisco County Medical Society, Sept. 12, 1893.)

The Germans say: "The eye is never satisfied with seeing." It is then a fit type of the infinite hunger of the human soul for knowledge and truth, that proves kinship between mortality and immortality and between humanity and divinity. The eye of the scholar, ministering to this hunger of the soul, reaches, with the aid of the records of nature, into the dim ages preceding the existence of man. The eye of the skilled artisan or artist searches out and brings to us a wealth of treasure for our material comfort and happiness. The eye of the lawyer and doctor brings forth many hidden things for our weal or woe.

The study of the eye reveals not only much of great practical value, but leads as well to a deep philosophy. Witness one sentence from the works of the great Von Graefe: "Be the idea what it may, that we form to ourselves of the mysterious tie that links our perception to the life of the soul, so much is undoubted, that the material supplied by the impressions of the senses constitutes the basis on which the soul unfolds; further, that they furnish the nutriment on which our thoughts and conceptions live and grow, and that through them alone is preserved the connection between the invisible 'I' and the external world, the soil in which all conscious intellectual activity strikes root."

It is said that "he that would rightly understand a man must read his whole story." Who can do this? Yet a measure of truth is thus expressed. Sure it is that the main portion of the story of life passes into the soul of man through the eye. Then it is not strange that the keen observer can read in the eyes of

those about him the story of life, its needs and hopes. Ah, the needs of man. They are of sterner stuff than his hopes. No wonder, then, that he struggles continually against this limitation upon his happiness and slowly but steadily narrows the field of his hopeless needs, that he may enlarge that of his satisfied longings. But even in doing this he enlarges and multiplies his necessities.

Perhaps at no physical point has the development of man borne more heavily upon him than in the matter of his eyesight, notwithstanding the wondrous power and facility of that sense and the marvelous inventions in its aid. The eye is the nurse and foster mother of all the other senses and the patron of all the arts and sciences, and the modern man is looking minutely into a myriad of things and taxing his eyesight accordingly, and many are the hopes that have failed, and bitter has been the disappointment, when eyesight has given way under stress and ceaseless burden of the varied avocations and professions of modern life. At last we are beginning to realize what an endless train of terrible evils attends upon the breaking down and destruction of the eye under this stress and burden. But as yet there are only a few who catch even a glimpse of the importance of our subject with relation to our time and place in the history of the human race.

The ancient man (unless there be ancient civilization utterly lost to history) was, in the main at least, content with a broad and cursory view of things. He did not seek to search out the heart of a microbe nor seek to draw down into his field of vision unseen stars, and he knew nothing of that bondage and slavery of the eye—the printed page. The ancient man had no need for the study of optics or the science of ophthalmology, but the modern hath most urgent need, and is blinding himself and wrecking his nervous system and leaving a legacy of weakness and error to his children because of the lack.

At first sight it may seem strange that the scientific development of the diagnosis and treatment of diseases of the eye belongs to the last fifty years, but such fact is doubtless due to some radical and sweeping change in the needs and habits of men in a comparatively late period, bringing about for the first time, so far as we know, the necessity for such knowledge and treatment of the eye. To such change and necessity, in some most practical aspects, I shall ask your attention, confident

that they will not only interest you but prove most worthy of study.

Much time and study have been given during the past ten years to that particular branch of ophthalmology known as refraction and accommodation and their anomalies, also to the varied and peculiar nervous phenomena consequent upon long continued uncorrected visual errors. Both at home and abroad there is a rapidly growing recognition that visual disturbances, on account of their far-reaching influence, are becoming more and more an important factor in our every day life. It is possible that there has been a higher degree of scientific work performed by some investigators in Germany and France, yet I believe that we can safely say that nowhere else is there to be found a quicker apprehension of the real value of the labor of others or greater readiness to make practical use of material, from whatever source obtained, than in our own country. We have many earnest, conscientious, painstaking workers, who, perceiving the vast importance of this subject to mankind at large, have given much of their time and patience to collecting all the facts possible, of a statistical and clinical nature, connected with it. The great variety and number of articles of a popular as well as scientific nature, touching upon this question, which of late have appeared in numerous journals and papers, attest the widespread interest taken in "our eyes and their defects."

We all understand that the eye ball is an optical instrument of wonderful capacity to meet the varied and continuous demands made upon it, and that volumes have been and can still be written concerning it; so it is clear the scope of this paper must be limited and comparatively narrow in its field and be clearly defined, and it therefore seems wise at this point to definitely fix in mind the meaning of certain terms as used in this article, and to call especial attention to certain fundamental and controlling facts for present consideration.

The cornea, aqueous, lens and vitreous, together, constitute the refractive or dioptric apparatus of the eye. This medium, which is transparent, is composed of surfaces varying in curvature and density.

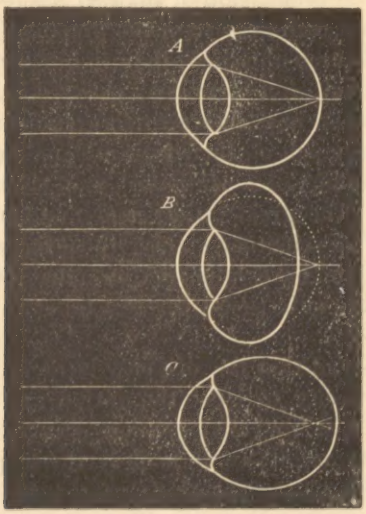
By refraction we understand the effect upon the rays of light passing through the medium, that is, through this apparatus when the eye is at rest.

The emmetropic or normal eye, as that expression is used in this paper, is purely an arbitrary term, meaning that when the eye at rest is looking at an object twenty or more feet away, the rays of light from that object received in the eye will focus upon and form a clear and distinct image upon the retina. (See A, Fig. 1.)

So also the hyperopic eye means one in which rays from twenty or more feet entering the eye will focus at a point beyond (that is behind) the retina. (See B, Fig. 1.)

So also the myopic eye means one in which the rays from twenty or more feet entering the eye will focus at a point in front of the retina. (See C, Fig. 1.)

Fig. 1.



So also astigmatism means only irregular curvature of the cornea, causing the light so entering the eye to focus at irregular distances, producing a confused image upon the retina. The general refraction of such an eye may be emmetropic, hyperopic or myopic.

Errors of refraction, or visual errors, as those terms are used in this paper, mean hyperopia, myopia and corneal astigmatism.

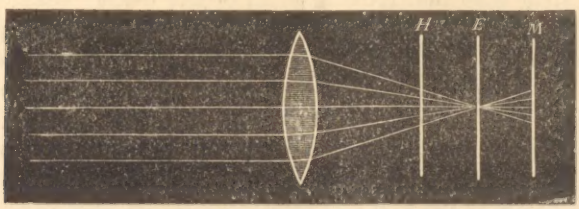
Muscular asthenopia, or weak sight, as those terms are used in this paper, mean that weak and exhausted condition of the

ciliary and recti muscles, which renders them incapable of properly performing their functions.

It is essential to recollect that, in the foregoing definitions of hyperopia and myopia, the eye is at rest, and by this it is meant that there is no action of the ciliary or recti muscles; also that the rays of light coming to the eye from an object twenty feet or more away are, in physiological optics, considered as parallel, but when they come to the eye from an object nearer than twenty feet they are divergent and that divergence increases as the object is brought nearer to the eye.

To make this point a little clearer, note the effect produced when a double convex lens (Fig. 2) is introduced in the pathway of parallel rays of light. In passing through this media the rays become refracted or bent and meet at a point on the Screen E. This is the focal point of the lens and represents the state of the emmetropic or normal eye when at rest. (A, Fig. 1.) Move the screen forward to H, and there will be an indistinct image similar to that seen in the hyperopic eye. (B, Fig. 1.) Similarly moving the screen backward beyond the focal point to "M" a blurred and indistinct image will be produced as seen in the myopic eye. (C, Fig. 1.)

Fig. 2.



It is also well understood that myopia and hyperopia may be produced by displacement of the lens backward or forward, according to the increase of pressure in the aqueous or vitreous chambers, and hyperopia may be and is not infrequently brought about by displacement of the retina forward; but these are due to pathological changes of a transient nature and are not to be reckoned as refractive errors.

In order to get clear vision with a myopic eye, the object must be situated at such a distance within twenty feet from the eye that the divergence of the rays of light will equal the error of refraction and therefore come to a focus upon the retina; or else the object at the distance of twenty feet or more away may

be looked at through a concave glass, which will sufficiently refract the rays of light in divergence to equal the error of refraction in the eye.

But nature has provided in the eye itself means to neutralize hyeropia, for the ciliary muscle, by causing the lens of the eye to contract in its width and increase in its thickness, as compared with its condition when at rest, enables the person looking at an object to change the angle at which the rays are refracted in passing through the lens and hence carry the focus backward and thus correct the hyperopia. There is no power in the eye to neutralize myopia, because it does not possess any means for carrying this focus backward, the structure of the eye being such that there is no way by which the width of the lens can be increased and its thickness decreased (or, in other words, the lens flattened or made thinner) as compared with its condition when at rest.

It is well to remember that an emmetropic eye becomes in effect hyperopic the instant it looks at an object within twenty feet, and the myopic eye also becomes in effect hyperopic when the object looked at is brought so close that the divergence of the rays of light coming to the eye from the object more than equals the myopia.

It is clear then that looking at an object nearer than twenty feet naturally calls into play in the emmetropic and hyperopic eye the ciliary muscle or power of accommodation, and the same is true of the myopic eye, if the object is brought so near that the divergence just spoken of more than equals the myopia. But there is another matter of great importance. The recti muscles are those muscles which guide and direct the eye in every rolling movement of the ball and in all its motions, and one of their most important functions for our present consideration is that of causing the eyes to converge towards each other; it enables a person, whenever looking at an object within twenty feet, to cause the eyes to converge more and more towards each other, as the object is brought closer and closer, thus offsetting and neutralizing what would otherwise be the increased divergence of the rays of light passing into the eyes, thus keeping the focus of each eye, and therefore the images, at the same relative point or position of the retinas of the two eyes.

To the thoughtful mind the mere statement of these facts and principles at once draws attention to the marked difference between the requirements, necessities and burdens of the modern

or civilized eye and that of the savage. The ancient man, almost without exception, and the modern man who follows the calling of the sailor or farmer or the like, use the power of accommodation but rarely as compared with the typical man of the 19th century, and while the ancient man or the sailor or farmer or the like puts his power of accommodation to constantly varying and little strain, the student pouring over his books or the artisan in near work subjects that power to incessant and tremendous strain, often long continued without any practical variation. Here we have the two classes of men, one typical of the olden days and the other typical of modern civilization, the one doing those things which tend to keep the eye in a healthy condition and the other doing those things hour after hour, by day and by night, and year after year, that absolutely (and this is no exaggeration) tend to tear in pieces and destroy the very structure of the eye itself.

The hyperopic eye (nature's eye) overtasked with near work tends in itself and subsequent generations to become myopic. For example, the ancient Germans, with what Tacitus calls "fiercely blue eyes," occupied with war and the chase, have gradually developed into the typical scholarly race of the 19th century, suffering frightfully from myopia, to which the old German style of printing types largely contributed, in some institutions of learning this defect reaching as high as 80 per cent.

It may be said that the principal avocation of the German nation is still war or getting ready for it, but the average German must spend many hours a day for many years at school. Her officers excel in technical studies, and the nation is learned in the wisdom of the schools to a point that sometimes seems to us a weariness of the flesh. So it is not strange that, in view of what we have already noted, the necessities of the Germans should have caused them to learn some great lessons in optics and ophthalmology. We may well avail ourselves of their dearly bought wisdom in these matters at least.

Asthenopia usually results from a too prolonged use of the eyes at near work without proper care and assistance, and is almost sure to follow neglected errors of refraction in eyes so employed. It is only three or four years since attention has been particularly drawn to the remarkable part played by the recti muscles in defects of the eyes.

It is generally acknowledged by oculists[1] that from ninety to ninety-five per cent of all patients who consult them about their eyes suffer with some form of refractive error, existing either alone or in combination, or with some of the varieties of muscular asthenopia.

I am inclined to accept muscular asthenopia as a disturbance primarily due to visual error, for the reason that I have always found an error of refraction present in all such cases.[2]

Von Grafe looked upon or considered asthenopia as a symptom only.

"It is my belief," says Roosa, "that in the refractive condition of the eye will be found the source of any insufficiency or of any want of equilibrium of the muscles of the eyeball. * * * * Insufficiencies are effects of errors of refraction and not *causes* of asthenopia. * * * * Very slight differences between the two eyes (anisometropia) have been a cause of great suffering; these causes have often proved baffling, until complete paralysis of accommodation has disclosed the real facts in the case."[3]

To the same effect another writer says: "I am of the opinion that the eye strain makes faulty ocular muscles, and generally, the ametropia satisfactorily corrected, the muscles will not be a disturbing factor."[4]

There is a growing conviction that there is a vast amount of physical suffering from headache, eye strain, anisometropia,[5] strabismus, debility, dizziness, vertigo, loss of power of concen-

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[1] Gould, *Jour. Am. Med. Assn.*, Sept. 19, 1891, p. 432. Noyes et al., "Ametropia exists in 90 per cent of the human race." Roosa, *N. Y. Med. Jour.*, March 28, 1891, p. 354.

[2] Donders says in the pure form of asthenopia, hyperopia is scarcely ever wanting or some low degree of astigmatism. See also a very valuable paper by J. W. Wright, M. D., in the *Journal of the American Medical Association*, March 29th, 1890, on ametropiæ and their relation to insufficiencies of the recti muscles, in which he says. "I believe there are very few cases of insufficiencies without an error of refraction."

[3] *New York Med. Jour.*, March 28, 1891, p. 353, *et seq.*

[4] Peter A. Callan, *Jour. Am. Med. Assn.*, March 28, 1861. p. 438.

[5] Dr. Gould says, "that not only is anisometropia (unequal vision of the eyes) provocative of great disturbance, but in the worst cases the diseased eye can be treated and exercised to become useful." Cases are detailed.

tration, impaired memory, melancholia, insomnia,[1] epilepsy,[2] chorea,[3] nystagmus, and other forms of nerve disturbances, which have not infrequently been known to have had their origin in some one or more of these refractive errors, the discovery and correction of which have again and again restored patients to health and happiness.

Nor are the evil results of overtaxing of the ciliary and recti muscles limited to nervous disturbances. Overtaxing of the ciliary muscle in the hyperopic eye in near work naturally tends in the individual and his descendants to the production of a myopic eye, and the latter tends to grow more and more myopic and to result at last in a practical disruption of the retina, the most vital portion of the eye, finally ending in partial or total blindness. Overtaxing of the recti muscles in near work also tends to a somewhat similar practical disruption and final result.

A slight examination of the statistics accompanying this paper shows that the greatest number of individuals examined were between the ages of ten and twenty-five years, viz. 56 per cent, or more than one-half of the total number examined. During these years the eyes are called upon to perform the greatest amount of continuous work. This is also a period when the whole physical system is passing through all the phases of growth together with the rapid development of the faculties, and the foundation is being then laid that shall mean subsequent bodily vigor or weakness.[4] At this time, also, we find refractive errors, if present, are quite likely to become developed, together with the varied and peculiar phenomena of nerve irritation, such as fretfulness, ill temper, weakness, capricious appetite, sleeplessness, night terrors, etc.[5] The amount of

[1] "Clinical evidence goes to show that a large proportion of subjects affected with persistent insomnia of long standing suffer from some congenital defects of the eyes themselves or from an improper adjustment of the muscles that move the eye."—*N. Y. Med. Jour.*, March 23, 1891.—*Ranney.*

[2] & [3] Ranney, p. 356, p. 357, *N. Y. Med. Jour.*, March 28, 1891; also Webster, in *N. Y. Med. Jour.*, March, 1888, p. 274. See also Ranney, "Lectures on Nervous Diseases," p. 470. He has classed epilepsy and chorea among the functional disturbances. See also Dr. De Schweinitz, *N. Y. Med. Jour.*, June, 1888, title, "Chorea in Children."

[4] At fifteen to eighteen years of age eyes are supposed to be at their highest state of efficiency, capable of the greatest endurance.

[5] "I desire to emphasize the fact that 'eye strain' constitutes in a large proportion of such cases a factor that is often unrecognized or ignored by medical men."—*Ranney.*

nerve energy, which should be reserved for necessary work, thus spent, trying to overcome a remediable defect, must be something tremendous. In these cases there seems to be a constant warfare going on between nature trying to minimize the consequences of its own errors and the errors themselves. It is only a question of time, should we not correct these errors, when nature will give up the contest, the patient may be obliged to discontinue all forms of near work, and may suffer nervous prostration or other nerve disorder, from the consequences of which he may never fully recover. The history of ophthalmology is full of such cases, happily not so numerous at the present time as twenty years ago.

The economic value to society of this subject is of no less importance than the clinical. Physicians are not, as a rule, apt to look upon disease outside of its effects on the individual himself. To discover the nature of the disease in any given case, to treat it, to follow its course to the end which also terminates all responsibility on the physician's part, would appear to be the usual method. If, from any cause, as accident or sickness, one or more individuals are withdrawn from the right performance of their allotted share of work, the most marked disturbances and losses are, of course, to the individual and his immediate family or circle of friends or co-workers, but society is itself disturbed in even such individual cases, for society is but an aggregation of individuals and, as the highest efficiency of each individual can only be obtained where his duties are performed without loss of time and strength, so the highest efficiency of society can only be obtained where all its members are enabled to perform all their duties without mental or physical waste. This is true in all cases and is sometimes very marked even where only one or a few of its members are stricken or hampered with disease. Society is a delicate interadjustment of all, and to certain individuals falls a heavy share of responsibility and usefulness, and when they are partially or wholly withdrawn society often suffers severely. Then when an epidemic, such as smallpox or cholera, often starting at a given place from a single person, extends over a whole community, the state itself may feel the shock, and all become strongly impressed not only with the danger to and loss of life but also the results of enormous industrial and material loss. But there are widespread diseases and dangers to health that involve whole

communities and nations—the race itself—that do not startle us because the results are not so sudden and sweeping, and because their advances are insidious. But they are all the more dangerous for such reasons. The mere chance that some dread pestilence may steal upon us unawares causes society to enact laws regulating and prescribing the manner in which all its members shall conduct themselves in many things that are ordinarily considered none of society's business, and we all recognize the need for such laws and make vigorous demands that they be enforced. Yet I must unhesitatingly say that, not only is there a greater menace (because from disease actually installed in our midst), but also an incalculable material waste of life and all that makes life worth having, in every community in our land on account of imperfect eyes. This may seem to you at first exaggeration, but I assure you it is not, and we are blindly yielding up untold treasures of life and happiness that should never be surrendered. This waste is taking place, slowly it may be and silently, but none the less surely and needlessly among all classes.

There is no profession, no business or trade of any kind which is not, in some degree, dependent upon accuracy of vision for success. To illustrate: at some critical moment, a mechanic, while attempting a piece of work requiring the greatest possible accuracy of vision, may, on account of a defect of his eyes, of which he may possibly be ignorant, cause a loss to be reckoned by thousands of dollars and be charged with carelessness or bad judgment. And what shall we say of the accuracy of sight required from others in infinitely more responsible positions. Such examples of carelessness or errors of judgment have been known to take place again and again, and they will continue to take place until those whose who are the most interested compel an examination of the eyes. Can we demonstrate to employers of skilled labor that upon the condition of a workman's eyes may depend the saving or loss of great property interests at critical moments, to say nothing of the possible general efficiency and skill, we are quite likely to obtain a hearing for any proposition to better the present condition of the public eyesight and especially to test and correct that of their particular workmen. Every department of mechanical industry is liable to unnecessary accidents heretofore possibly reckoned among the unavoidable and sometimes inexplicable accidents.

A rather interesting, even if very homely, illustration of this phase of the subject came under my own observation some two or three years since. A carpenter found that he was getting into the habit of striking his thumb and finger of the left hand with his hammer while he was attempting to start a nail. After a time he concluded that something besides his hammer was at fault. It was suggested to him that he might have some trouble with his eyes. On examination I found that he had hyperopic astigmatism of both eyes, combined with weakness of the external recti muscles. We found that objects had a slightly blurred outline, the nailhead appearing faintly doubled with each eye.[1] There was not a clear, well-defined image upon the retina. Binocular vision could not be maintained for any length of time. The power of accommodation which had for years been taxed to overcome the defect had finally weakened. Correction of the astigmatism relieved this man of all trouble, and he is now capable of working at his trade with comfort to himself and satisfaction to his employer. But if this trouble had not been remedied, it requires no great stretch of imagination to see that by some accident his family might have been deprived of the support which he now easily furnishes and he have become a burden upon society, and the whole affair been classed as an inexplicable act of Providence. We can parallel this case with many others in the everyday practice of every oculist.

And there are accidents that have become so frequent and alarming that the accumulation of losses and the gravity of the dangers involved have literally compelled a search for the cause, resulting in proof that it lay in defective eyesight. There is a class of wage-earners upon whom the greatest and gravest responsibility rests, for life as well as property is always at stake. I refer to engineers and pilots. Through imperfect vision on their part millions of dollars have been lost and thousands of lives have been sacrificed. Through misinterpretation or failure to see the proper signal, frightful accidents have happened. Read the account of the collision between the steam tug "Lumbarton," the steamship "Isaac Bell" and the steamer "Austria;" also the more dreadful collision between the "Vanguard" and "Iron Duke;" and finally the collision

[1] This must not be confounded with diplopia due to paralysis of one or more of the recti muscles, or to diseases of the brain. See also Dr. Thompson in *Jour. Am. Med. Assn.*, p. 400.

between the steamer "Toronto" and bark "Freidir," as related by Birkerton [1]: the cause, color-blindness; the result, a horrible waste of property and life. This author says: "This subject is not a medical one, it is a national, or rather international." It is a most significant fact that, at an examination of pilots between 1880 and 1886 by the United States Marine Hospital Service, 2½ to 3 per cent were found color-blind. [2] This in a service supposed to be composed of individuals of high degree of efficiency in the matter of eyesight and with reference to only one defect, color-blindness. In addition, when it is understood that over 50 per cent of all our engineers and pilots have some well defined error of refraction, we get some faint comprehension of the dangers involved.

No wonder that one great and progressive corporation has found it not only profitable but necessary to maintain a systematic examination to discover and protect against such errors. And this is the more significant when we learn that such corporation (soulless if you please) has found it profitable, if not necessary, not only to maintain such regular examination, but, after every accident (even if it be reported as an "Act of God" as their lawyers term it), to have a searching re-examination of every person connected even in the most trivial way with the accident. It would seem that a desire to protect and save themselves from being mulcted in large amounts for injury and loss of life would convince any corporation of that character that there must be economy in having thorough examination of every employe's eyes. What pays a corporation will certainly pay society, in so far as practicable.

I examined an engineer who was so defective in vision that he could not distinguish a signal one hundred yards from his engine. Having had many slight accidents, an examination was ordered, when it was discovered that he was suffering with progressive disease of both optic nerves. Incidentally it was learned that he was saved from serious disaster by relying upon the eyes of his fireman. The public are startled when such a fact is revealed, but such hidden dangers are on every side and none the less effective for evil because hidden; rather the more so. Yet, great and irreparable as is the loss of human life, the aggregate

[1] *British Medical Journal*, Nov. 10th, 1888.

[2] Pilots color-blind, 3 per cent; revenue marine, 1 per cent; seamen, ½ of 1 per cent.

of other losses is tremendous. Naturally the public learn first (as do individuals) to protect from the more patent dangers and the losses which, when seen, are the most impressive. So it is natural that the dangers caused by the defective eyesight of railway employes were among the first to receive wide public notice. But if life is worth keeping it is worth living well. The difference between the savage and the civilized nation is but an example of this. If a savage nation should pour forth upon one of the family of civilized nations an irruption destructive to the treasures and powers of that nation, the whole civilized world would stand appalled, but that such savage nation should itself remain undeveloped, bound in its chains of ignorance and weakness, is, to the clear thinking man, also appalling. For that which might have been, the wise man mourns as for that which was, but is lost. We owe a duty to those that come after us commensurate with the legacy of the ages which has been bestowed upon us. And it may be that this duty is even of greater social importance than the protection of a comparatively few individual lives. The treasures, material and mental, that make life worth keeping are themselves something of a measure of our duty to enlarge and carry on this work of material and mental development. Every flower of ornament that art has or may produce, every substantial comfort that the artisan has or can provide, is but an example of the opportunity and the duty, the reward and the necessity, that form the interwoven texture of society.

We have been speaking in general terms but all who read or hear can readily supply practical illustrations. No walk in life is so humble, if it be honest, (and by honest we mean connected rightfully with the true welfare of our fellowmen) as to be without numberless opportunities and examples of the losses which occur, not only to ourselves but to untold generations dependent upon us for life and the means that shall make it ever the more worth having, by reason of ignorance or wilful neglect of remediable defects and imperfections. Such neglect is criminal in the truest moral significance of the word. It is true that human life is of transcendant importance as compared with mere material things, but of what worth is life saved to unhappiness? It is a punishment and a disaster instead of a blessing and a reward. Society is composed of many and diverse elements. That such elements should have, as far as possible,

unhampered ability to pay their debt to society and redeem their obligation to the future is of great importance. But when we remember that such elements are themselves human beings, like unto ourselves, we also see that their happiness while engaged in such work is also of great importance. Fortunately but a few of our fellowmen are blind. We are awaking to the fact, however, that only a few of our fellowmen are perfect, even in their eyesight. Blot out from among the faculties of humanity the power to see, and who has the command of language to express the breadth and weight of such disaster? He who maketh the blind to see rightfully earns most profound gratitude and confers a blessing, the limits of whose results no man can ascertain. Fortunately, the need to bring sight to the blind is comparatively rare, but it is now demonstrated beyond question that the need for aid in the correction of those errors and defects in the eyesight which seriously menace the safety and happiness of a majority of our fellowmen is one that impinges upon and radically affects every conceivable relation of life. Volumes might be written in illustration of this and of the immeasurable importance and responsibility laid upon all those laboring in this field or having power to advance or retard its development.

It is not many years since the oculist who would send an able and brilliant intellect clouded with the defective means of vision into retirement and obscurity would be looked upon as having taken the only means possible to avoid a greater disaster. For example, McKenzie, probably the most eminent oculist of his time, in speaking of asthenopia and his inability to cure certain cases, says: "I advise those who are in circumstances permitting to emigrate, telling them that, though they never could employ their eyes advantageously where much reading or writing was required, they might see sufficiently to follow the pastoral pursuits of an Australian colonist." But the oculist of to-day who should take such a course would, at least in many cases, be demonstrating a criminal unfitness or ignorance (and such ignorance would itself, in some measure, be criminal) in his profession and relation to society. What then shall be said of the employer who not only neglects the opportunity which he has to assist in this needful work but actually becomes a hindrance and stumbling block in the road of those who, by their misfortune, are left helpless in large measure under his control?

But such obstacles we do encounter in our work and that not infrequently, when examining the eyes of a certain class of employes, evidenced by the common remark, "If I am caught wearing glasses my boss will let me out of my job. He never employs men who are obliged to wear glasses continually." There is no question but that this is due to a mistaken notion of the real nature of the case. The act of wearing glasses about their work is looked upon as a confession of weakness of eyesight by their employer, when the wearing of glasses should be evidence that intelligence and skill has in this case guaranteed good eyesight. The man who does not wear glasses, unless he has been tested, is the one about whose eyesight there is a doubt. Should such a rule against employing those who wear glasses be universal, the unfortunate consequences may be easily foreseen. For example, a workman, knowing his defect, would conceal it to the last extremity, continuing to do poor work and cause loss both to himself and his employer, rather than take any chance of losing his place and perhaps thus bringing himself and his family to distress and burdening society still more.

Just as we first realize the importance of human life and the need for testing the engineer for color-blindness, so in this broader field we first realize the needs of special callings. Bookkeepers, type-setters, type-writers, sewing girls, artists in china painting, those who do fine needle work, retouchers of photographs, in fact all who, on account of the nature of their business, are obliged to use their eyes at close range for several hours daily, form a class, having less responsibility than engineers and pilots and those entrusted with human life directly, yet, on account of poor eyesight, may, through loss of time and their danger of making mistakes, cause pecuniary loss to their employers and run the risk of losing their positions as skilful wage-earners and become burdens upon society, to say nothing of the great aggregate loss of human happiness. Such workers are very apt to have nervous prostration on account of nerve-strain produced by too prolonged eye-tension—muscular asthenopia is the form most generally noticed. A great majority regain their power to work as soon as their error of refraction is corrected. The objection to wearing glasses by this class of workers is usually on sentimental grounds, and, as a rule, prevails among women only. The mass, however, are usually quite

willing to accept the aid of glasses as soon as they become convinced that they must wear them or discontinue work. They are, as a rule, ignorant of their exact condition. The person under 35 years of age, who, when at close work, discovers that occasionally his figures or the printed lines run into each other and there is a desire to look off for a moment to rest the eyes, or finds it necessary to be particular about getting into a good light, or to seek for larger print, or complains of smarting or feeling of grit in the eyes, or watering of the eyes, or stickiness of the lids in the morning, or occasional headache or twitching of the lids or facial muscles, is pretty apt to have some error of refraction which is rapidly developing into "eye-strain" with its consequences. The sooner such eyes are examined and corrected, the better for them and their employer and for society. Time and money and health are being sacrificed. Loss of health, influence upon character,[1] loss of property and loss of life, and loss of that happiness which alone can make life worth keeping, having been found to follow as a consequence of imperfect vision, you will, I think, comprehend in full the proposition that a person with defective eyesight exerts an influence far beyond himself. It is not too much, therefore, to suggest that every physician familiarize himself, as far as possible, with the simple laws of refraction and accommodation, with the common method for testing acuteness of vision, and the consequences liable to follow uncorrected refractive errors, especially on the young, because such errors long neglected are apt to result in permanent lesions of the retina. "Physicians should be able to differentiate between a strabismus caused by hyperopia and paralytic strabismus, between the ordinary forms of iritis and specific iritis."[2]

It is, after all, the general practitioner who will, in the vast majority of cases, have to decide whether or not his patient shall consult an oculist. For this reason I consider the responsibility borne by the general physician broader and more far-reaching than that of the specialist.

The intimate relation between the eye and brain must never be forgotten. A true appreciation of the anatomy and physical

[1] See Collen, *Loco Cit.*, p. 443.

[2] R. L. Knaggs, M. C., Cantab., *Lancet*, January 14, 1893, p. 76. Art. "An ophthalmic knowledge considered as essential to general medical and surgical work." See also Gower on Medical Ophthalmoscopy.

connection between those parts of the nervous organization is of vital importance. It must always be remembered that the eyes are parts of a living organism and can not be successfully treated as mere mechanical instruments.

We cannot bear too strongly in mind the intimate connection known, by every medical man, to exist between the various organs of the body and the eyes.[1] It is a well known fact, not only to the profession but to all who have the care of children, that after scarlet fever, measles, diphtheria, whooping cough and similar disorders, various disturbances of the eyes are almost sure to develop. The oculist knows that such disturbances are the development of latent refractive errors, and he also knows that in convalescence from any serious illness the eyes should not be used for any continuous near work.

In very many cases women at the catamenial period have developed peculiar nervous phenomena of the eyes wholly reflex,[2] such as flashing of light, floating spots, imperfect vision, "trembling and loss of steady control of hands and head."—*(Gould.)* Cases are known where at such times errors of refraction, before unsuspected, have suddenly become developed. Inflammations of the eyes, externally as well as in the deeper structures, optic nerve and retina,[3] have been known to be due to disturbance of the reproductive organs in women. Generally, in such disturbances of the eyes, unless due to traumatism or similar evident cause, we, as a rule, expect to find errors of refraction. It becomes doubly necessary to be on our guard and carefully examine the body as a whole, before giving a specific diagnosis. "The note-books of ophthalmic work are full of instances in which ocular conditions have had to be traced back to states of health which lie strictly within the domain of the general practitioner, and the treatment in many instances resolves itself into that which is needed for the general bodily state."[4]

The intimate relationship between the body as a whole and the field of the specialist, is also well illustrated by the fact that

[1] S. C. Ayres, Cincinnati, O. Address on Ophthalmology. *Jour. Amr. Med. Assn.*, May, 1890, p. 789.

[2] Mr. Power. *Lancet*, May, 1889. Diseases of eyes occurring in connection with pregnancy.

[3] A. M. Ramsay, M. D., Glasgow. *Lancet*, April 15, 1893. Diseases of Eyes in Gynecological and Obstetrical Practice.

[4] Knapp's *Loco Cit.*, p. 76.

specialists not infrequently have mistaken the symptoms for the cause. A good general knowledge of medicine, with carefulness of investigation of the general functions of the body, will assist in the prevention of such mistakes; hence we see the need for the greater intimacy and cordial co-operation between the general practitioner and the specialist, the need on the part of the general practitioner to recognize and use a portion of that knowledge and experience which has been developed by the specialist, and the need on the part of the specialist to continually remember that his work can not be properly or safely done without a continual knowledge of and allowance for the needs of the whole body.

The hereditary aspect of this question should not be lost sight of; and while we will not at this time enter into an exhaustive discussion of it, it is well to bear in mind that defective eyes are almost invariably found to attend children of phthisical parents, and this defect is generally hyperopia, itself an example of arrested development. Such arrested development in the eye of the child may be traced directly to impoverishment of the bodies of the parents, caused by lack of nourishment, disease or excess.

Thus far we have been stating general principles and elementary matters illustrated by general examples, and leading to broad deductions. These results have been reached, however, by the close study of a large number of actual individual cases, and it is for this very reason that I feel assured they can be safely trusted as real and not specious. It may, therefore, be profitable to present those cases by charts and statistics, so that these results may be traced to the real sources of information and attested, and in doing this we may find further new and important truths.

Four years ago the examination of this series of 1300 errors of refraction was begun by me. At the end of two years my examination of this series was closed, since which time very careful study has been given to each case. I now present to you for your consideration an analysis of these cases, together with statistical tables and graphic charts arranged for easy reference. The material for this study has been wholly taken from my private case book and in regular rotation, there being no attempt at selection of cases to illustrate any one point. At the time of making these records I had no prejudices, preconceived

theories or pet hobbies to bias my mind. I have tried to set down all facts in each case just as they presented themselves to me at the moment of examination. After noting age and occupation, every symptom, no matter how apparently trivial, was recorded in the patient's own language, whenever practicable. It has been my purpose to get from each one what he considered his most serious disturbance. If headache was the principal symptom, its characteristics, such as its nature, time of occurrence, duration and frequency, were carefully noted with especial reference to work and position as to light and character of the latter. Of type-writers, stenographers, bookkeepers and clerks I now invariably inquire closely as to the character of the light under which they work and their position with reference to it. If electricity is the illuminant, it is important to know what protection is given the eyes. This is a very practical question at the present time, since the use of electricity is becoming so universal, and in many large public buildings, factories and business places it is the sole method of illumination and in some cases is made to take the place of daylight. The light even from the incandescent is so intense that a moment's direct look without the intervention of some kind of a shade produces unpleasant sensations upon the eye. Constant work under such glare has been the cause of a great deal of eye-disturbance, and almost daily I am meeting with cases directly traceable to this as a cause. To render such light harmless it is only necessary to shade the light with ground glass, or even tissue paper.

If the principal disturbance complained of by the patient was blurring of the print or running together of the lines, or similar difficulty, its frequency, duration and general effect on the eyes were carefully noted. If the eyeballs occasionally got red, I noted whether it was after use at near work or under what circumstances. Blepharitis—inflammation of the edges of the lids and formation of crusts—a very frequent disturbance in the eyes of children, always causes particular inquiry. For example, was it found to be less troublesome during vacation season? Keratitis—ulceration of cornea and conjunctiva—caused similar inquiry. As to these two troublesome complaints, I wish to put myself on record to the effect that I have yet to see a case of blepharitis or keratitis that did not have an error of refraction, the correction of which has, sooner or later, brought about a

cure. The ordinary application of yellow oxide of mercury or other remedies to the lids, and constitutional treatment, is not to be neglected. By the use of these and rest from work the patient will get well, but to remain thoroughly so the error of vision must be corrected. All forms of nervous disturbance were especially noted, such as muscular twitching of lids or of the face so frequently seen and found to have a close connection with defects of the eyes.

Having obtained these facts, the examination was continued by testing each eye separately and carefully with test-charts at a distance of twenty feet for visual acuteness. Other special tests were used, the recital of which is not at present material. To make the diagnosis more complete the ophthalmoscope and other instruments were then used, and thus the refraction accurately ascertained, whether hyperopic, myopic or astigmatic. The condition of the fundus, optic nerve and retina was always carefully examined for possible pathological changes. Many drawings of the disk and retina were made, revealing that in nearly every case of hyperopia there was a deep porus opticus. My attention was first drawn to this point three years ago while examining the University students at Berkeley. Since then I have taken pains to see if this was a fact. An examination of over five hundred University students, in addition to these thirteen hundred eyes, has convinced me that this is a special peculiarity of the hyperopic eye. In high degrees of hyperopia it is generally very marked, especially in the young. I would be pleased to have other observers note this and see if my conclusions are correct.

In the work of tabulating these statistics I have grouped them according to ages, taking them for every five years up to thirty, then by decades thereafter. The tables have been arranged for easy reference by those of you who care to examine them more closely and at your leisure. The graphic charts have been made to assist the eye in determining the various points which it is hoped to develop. These charts deal wholly in percentages, while the tables deal with the percentages and the units themselves.[1]

[1] The vertical lines or ordinates indicate the age; the horizontal or abscissæ represent the results in percentages.

TABLE I.

TOTAL NUMBER OF EYES BY AGES; ALSO SHOWING THE RELATIVE PROPORTION OF THE SEXES, ON A BASIS OF 1300 EYES.

AGES.	TOTAL NO. EYES.	PER CENT.		MALE.	PER CENT MALE.	PER CENT	FEMALE.	PER CENT FEMALE.	PER CENT.
5–10	104	8.00		38		2.92	66		5.08
10–15	216	16.61		80		6.15	136		10.46
15–20	298	22.92	56	84	55.23	7.23	204	55.23	15.69
20–25	214	16.46		58		4.46	156		12.00
25–30	162	12.46		50		3.85	112		8.61
30–40	126	9.70		38		2.92	88		6.78
40–50	104	8.00		26		2.00	78		6.00
50–60	52	4.00		12		0.93	40		3.07
60–70	24	1.85		6		0.46	18		1.39
	1300	100.00		402		30.92	898		69.08

CHART A.

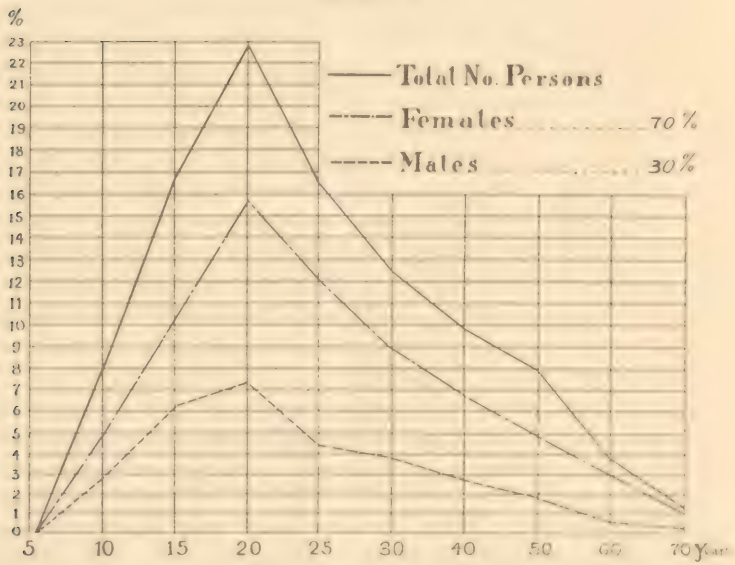

Table I and Chart A have to do with the percentage of eyes examined for each age and the proportion according to sex. The principal feature to which I would ask your attention is the abrupt and rapid rise of the curve from the tenth year, reaching its climax at the twentieth year, then descending equally abruptly. The jump from 8 per cent at the tenth year to 16.61 per cent at the fifteenth year is particularly worth

noting; *i. e.*, there were something over twice the number during the five years' interval from ten to fifteen than there were between the fifth and tenth year. The jump between the fifteenth and twentieth year, though large, is not so great, being but 7 per cent, yet this is to be noted as being the culmination of the curve in this as well as all of these charts.

It will be found no less instructive, as well as interesting, to consider the two minor curves in Chart A, which indicate the proportion of the sexes, females being 70 per cent and males 30 per cent of the total number examined. Between 10 and 55 years of age the percentage is the same for each sex, viz. 55.23 per cent.

A moment's consideration will show that this disproportion is within bounds. By comparison with Dr. Gould's tables of about three thousand cases, it will be seen that he had 76 per cent females and 24 per cent males—a percentage even larger than mine. Taking the females as a class, we find that at a very early age they are taught to sew, and, as they grow older, more and more difficult tasks are set for their eyes in the matter of close work, that is, work at near range. At the school age, in fact all through school life, they are expected to do a large portion of their own sewing as well as attending to all their school lessons. Instruction in painting, music and embroidery, or some equally trying work, is pursued as a matter of course and in addition to their special work.

Girls are also more conscientious than boys in their studies. They are more ambitious to excel, and failure is more keenly felt by them as a rule. This may be in part due to a more highly developed nervous organization.

I have been asked if this difference of the sexes between 10 and 25 years of age might not be due to the greater attendance of girls than boys at school. I will briefly say that investigation shows that, up to the last two grades of the grammar school, the sexes are about equal. After that necessity compels a very large number of boys to leave school and go to work. The high school shows a larger attendance of girls than boys, yet at no time was there found to be a greater difference than 50 per cent. Consequently we must look elsewhere for the cause of this disproportion found in our tables.

TABLE II.

SHOWING THE NUMBER OF EYES ATROPINIZED.

AGES.	SIMPLE HYPEROPIA.	ASTIGMATISM.	TOTAL OF CASES.	PER CENT OF EYES ATROPINIZED	PER CENT OF 1300 EYES.
	EYES.	EYES.	EYES.		
10	23	19	42	8.71	3.28
15	45	86	125	25.93	9.61
20	43	93	136	28.21	10.46
25	34	40	74	15.35	5.69
30	6	46	52	10.78	4.00
40	11	20	31	6.43	2.38
50	5	13	18	3.73	1.38
60	4		4	.82	.30
	171	311	482	100.00	37.07
	Per Cent of all Simple Hyperopic Eyes.	Per Cent of all Astigmatic Eyes.			
	22.50	72.50			
	Per Cent of all Eyes.	Per Cent of all Eyes.			
	13.15	23.07			

In all cases of hyperopia or astigmatism I have endeavored to obtain the consent of my patients to the use of atropia for the purpose of getting a more exact knowledge of the error to be corrected as well as to save time. Of this series I atropinized 37 per cent only. (Table II.) This is a small per cent compared to the proportion I now atropinize, which is fully 90 per cent of all my refractive cases. I frequently and freely use homatropine and with good results, but also, very frequently, I am obliged to conclude the examination by using atropine. I will say here that I have never had a single ill result from its use. In the present series the relatively best results will be found among the astigmatics, for of these I atropinized 72½ per cent. I have also taken especial pains to record final results in these cases. I have examined quite a number for the second time, but they have been almost invariably those who were not atropinized.

The ability to see a given object at a given distance is called visual acuteness. The standard of visual acuteness has been generally agreed upon to be equal to twenty-twentieths (20-20), and this is called normal vision. Many eyes have vision equal

not only to 20-20 or to 20-16 but even to 20-10.[1] Now a vision that equals 20-20 does not necessarily mean that such an eye is free from error of refraction. On the contrary, it is the experience of all oculists that those of our patients who are the greatest sufferers from eye-strain are those who have a visual acuteness indicated by 20-20 or better. This acuteness of vision we know is brought about by the use of the ciliary muscles mechanically counteracting the error of refraction. Vision being normal, however, indicates the probability that there is no intra-ocular disease, and in so far it has value.

TABLE III.

SHOWING PERCENTAGE OF EYES HAVING VISION EQUAL $\frac{20}{20}$.

GROUPS.

AGES.	EYES.	PER CENT OF SERIES.	PER CENT OF ALL EYES.
5–10	66	8.81	5.07
10–15	133	17.75	10.23
15–20	208	27.77	16.00
20–25	135	18.02	10.38
25–30	75	10.01	5.76
30–40	79	10.54	6.07
40–50	49	6.54	3.76
50–60	4	.53	.30
Total...	749	100.00	57.61

Table III shows the proportion of those with vision of 20-20 or better, for the different ages by percentages; 57, 61-100 per cent, more than one-half, had so-called normal vision.

Not a single one of these cases having vision equal to 20-20 retained that acuteness under atropine. It is true that I have seen a few cases (not among these, however) where, under the effect of atropine, the eye would see equal to 20-20, but in every such case the same eye when free from atropine would see far better than 20-20, running sometimes as high as 20-10. Hence it is clear that in every case the paralysis of the muscle of accommodation causes a loss of power to see, and demonstrates the fact that the mere ability to see 20-20 is no indication whatever that there is no error of refraction.

[1] See Noyes, Diseases of the Eye, p. 23. Hartridge, Refraction of the Eye, p. 48.

The analysis of the symptoms accompanying these statistics shows that, among these very cases having acute vision, there were many who were the greatest of sufferers from the effects of errors of refraction.

It is to be remarked that 63 per cent of those having a vision equal to 20-20 were between the ages of 10 and 25; over one-fourth or 27.77 per cent were between 15 and 20 years of age. This is in accord with the fact that the muscle of accommodation is at its greatest strength at these ages.

TABLE IV.

GENERAL REFRACTION OF 1300 EYES.

VARIETY OF ERROR	EYES.	PER CENT OF H.	PER CENT OF ALL.
Simple Hyperopia.....	759	74.63	58.38
Simple Hyperopic Astg.....	52	5.12	4.00
Hyperopia with Astig.....	206	20.25	15.80
Total Hyperopia	1017	100.00	78.18
		PER CENT OF M.	
Simple Myopia.....	112	38.62	8.62
Simple Myopic Astig.....	118	40.69	9.06
Myopia with Astig.....	53	18.72	4.14
Total Myopia	283	100.00	21.82
Grand Total	1300		100.00

Table IV gives the general refraction of the whole series. I have given this table in order to compare my results with a similar table published by Dr. Gould two years ago.[1] On several important points there is a very close agreement. For example, we both show that over three-fourths of all our cases were hyperopic, Dr. Gould's percentage being 77 per cent, my own $78\frac{18}{100}$ per cent. By his table he shows a difference in percentage between hyperopia with astigmatism and myopia with astigmatism of but 3 per cent. My tables show a difference of only 2 per cent. He says "relative to its own group the cases of simple hyperopia have been nearly twice as numerous in hyperopia as those of simple myopia in myopia." My own tables show the same relative difference between the simple hyperopia and simple myopia.

[1]Gould, Statistics and Lessons of Refraction, *Jour. Am. Med. Ass'n*, p. 433.

TABLE V.

TABLE OF REFRACTION OF 1300 EYES.

AGES.....	SIMPLE HYPEROPIC EYES.....	PER CENT OF HYPEROPIA	PER CENT OF ALL	SIMPLE MYOPIC EYES.....	PER CENT OF MYOPIA	PER CENT OF ALL	ASTIGMATIC EYES OF EVERY KIND.	PER CENT OF ASTIGMATIC.....	PER CENT OF ALL
5–10	81	10.68	6.15	8	7.14	.61	15	3.49	1.15
10–15	120	15.81	9.23	10	8.93	.76	86	20.00	6.61
15–20	157	20.69	12.07	25	22 32	1.92	116	27.04	8.92
20–25	129	16.99	9.92	25	22.32	1.92	60	13.96	4.62
25–30	68	8.95	5.05	15	13.30	1.15	79	18.41	6.07
30–40	72	9.48	5.52	6	5.35	.46	48	11.18	3.61
40–50	69	9.09	5.30	10	9.93	.76	25	5.82	1.92
50–60	45	5.09	3.37	7	6.25	.53			
60–70	18	2.37	1.38	6	5.35	.40			
Total	759	100.00	58.38	112	100.00	8.62	429	100.00	33.00

TABLE VI.

TABLE OF REFRACTION OF 1300 EYES.

	SIMPLE H. AND H. + AH. EYES.	PER CENT OF ALL H.	PER CENT OF ALL EYES.	SIMPLE MYOPIA AND M. + A M. EYES.	PER CENT ALL MYOPIC EYES.	PER CENT ALL EYES.	SIMPLE ASTIG. AM. & AH. EYES.	PER CENT OF ASTIG.	PER CENT ALL EYES.
10	90	9.32	6.92	10	6.06	.76	4	2.35	.30
15	181	19.36	13.92	15	9.09	1.15	20	11.76	1.53
20	208	21.56	16.00	33	20.00	2.53	57	33.52	4.38
25	153	15.95	11.76	43	26.06	3.30	18	10.58	1.38
30	102	10.56	8.00	29	17.57	2.23	31	18.25	2.38
40	86	8.91	6.61	10	6.06	.76	30	17.65	2.30
50	82	8.40	6.00	12	7.27	.92	10	5.88	.76
60	45	4.66	3.46	7	4.24	.53	..	....	....
70	18	1.86	1 38	6	3.63	.46	..	....	....
	965	100.00	74.23	165	100.00	12.69	170	100.00	13.07

Tables V and VI, together with Charts B and C, are intended to illustrate the proportion which the various errors of refraction bear to each other.

CHART B.

Simple H, Simple M,
Ah and H + Ah; Am and M + Am

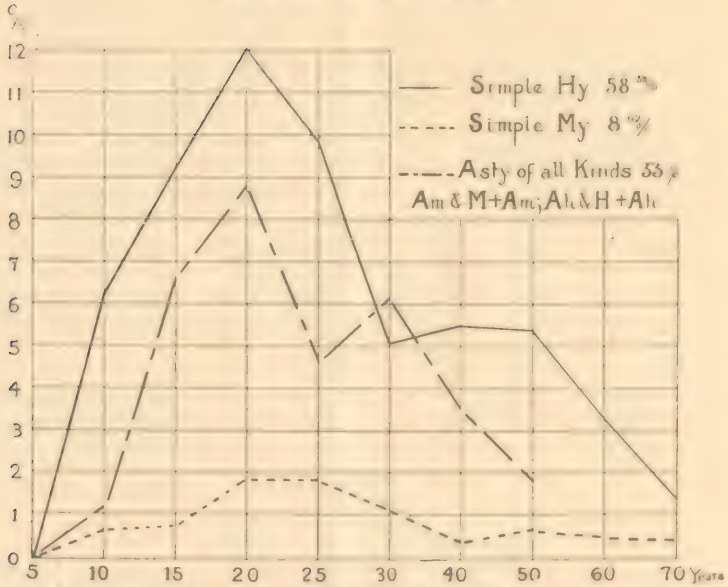

Table V gives the units with percentages of simple hyperopia (H), and simple myopia (M). It will be seen that hyperopia comprises over one-half ($58\frac{38}{100}$) per cent of the total number of units; myopia numbering only $8\frac{62}{100}$ per cent; while the remaining 33 per cent includes the total astigmatics. On Chart B the curves of hyperopia and astigmatism are seen to approach quite near each other at the twentieth year. This is due to the fact that with the astigmatics are included a large number of hyperopes and myopes. To approach, therefore, more closely to the true proportion which all hyperopes and myopes bear to each other, Table VI and Chart C were constructed. Here it will be found that in the first column I have given all hyperopes with astigmatism (H. and H. + Ah.); in the second column all myopes with astigmatism (M. and M. + Am.); leaving in the third column only cases of simple astigmatism.

The curves on Chart C show the results of this method of analysis, for if the cases of hyperopia and myopia are taken from the column of astigmatism and placed in the column of hyperopia, and curves constructed accordingly, the curves of hyperopia

and myopia will at once rise, while the curve of astigmatism drops to the lowest position.

CHART C.

H and H + Ah; M and M + Am, and Am and Ah

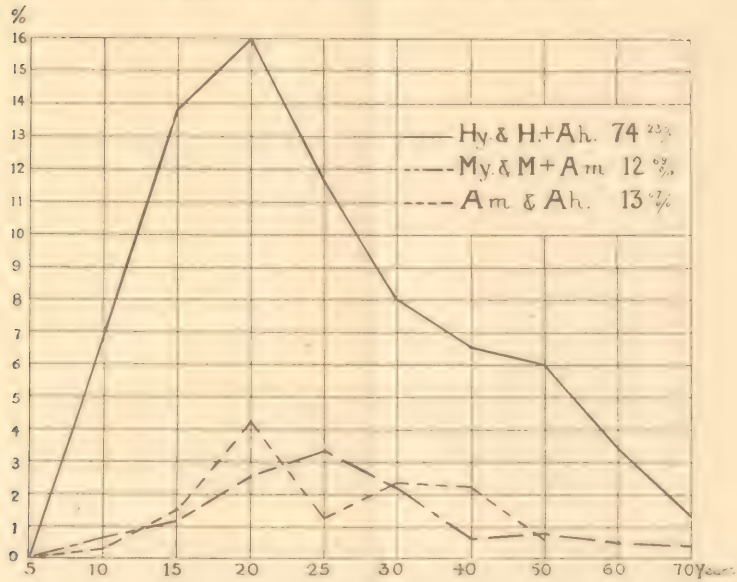

TABLE VII.

Refraction of 925 Hyperopic Eyes Expressed in Dioptrics.

Degrees. D.	Simple H. Eyes.	H. + Ah. Eyes.	H. and H. + Ah. Eyes.	Groups. Per Cent of all H.	Groups. Per Cent all Eyes.
0.50	26	20	46	4.97	3.53
0.75	159	54	213	23.02	16.38
1.00	263	42	305	32.97	23.46
1.25	98	34	132	14.27	10.15
1.50	41	15	56	6.05	4.30
1.75	23	8	31	3.35	2.38
2.00	32	15	47	5.08	3.61
2.25	9	8	17	1.83	1.30
2.50	10	7	17	1.83	1.30
2.75	3	2	5	.54	.38
3.00	14	6	20	2.16	1.53
3.50	10	4	14	1.51	1.07
4.00	5	1	6	.64	.56
4.50	3	2	5	.54	.38
5.00	3	1	4	.43	.30
5.50	0	1	1	.10	.07
6 00	2	2	4	.43	.30
7.00	..	1	1	.10	.07
8.00	..	1	1	.10	.07
	701	224	925	100.00	71.15

CHART D.

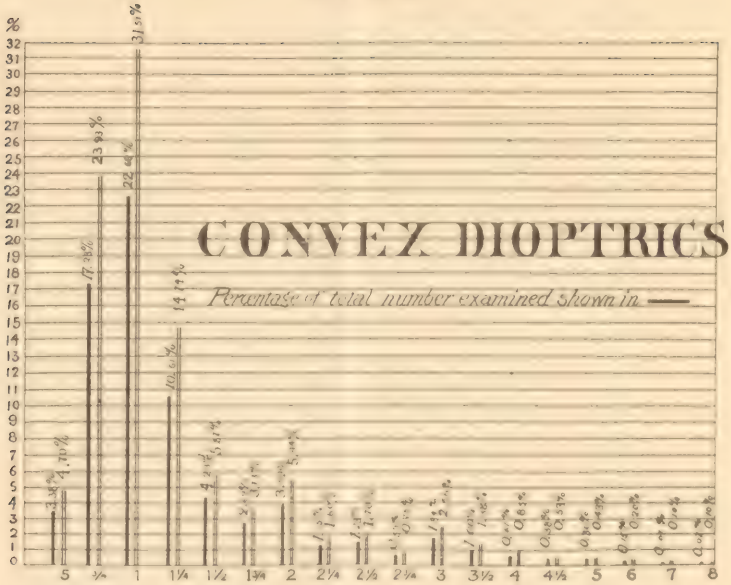

Table VII and Chart D give the refraction of 925 hyperopic eyes in dioptrics. This table is quite important as, with Chart D, it very clearly shows that the dioptrics of low power greatly preponderate, for we find that the three numbers .75, 1 and 1.25 dioptrics are over 70 per cent of the hyperopics and 50 of the whole series. The double lines give the percentage for the hyperopes, the solid black line the percentages for the whole series.

An analysis of the symptoms plainly shows that fully 80 per cent complain of headache or eye-pain as the most prominent symptom. We find also that those of our cases who suffered the most intensely with the various forms of nervous disorder are those who have been relieved with glasses of low power. It could be readily demonstrated (had we the time and space for that purpose) that these small errors of refraction easily corrected were the causes for such disorders. Having seen the intimate relationship that exists between eye-strain and low refractive errors, it would seem to need no further argument to show the necessity for correcting every such error.

TABLE VIII.

REFRACTION OF 164 MYOPIC EYES EXPRESSED IN DIOPTRICS.

DEGREES. D.	SIMPLE M. EYES.	M. & AM. EYES.	M. AND M. + AM. EYES.	GROUPS. PER CENT OF ALL M.	GROUPS. PER CENT ALL EYES.
0.50	0	3	3	1.82	.23
0.75	6	4	10	6.09	.76
1.00	10	9	19	11.58	1.46
1.25	9	6	15	9.15	1.16
1.50	4	4	8	4.87	.61
1.75	7	3	10	6.09	.76
2 00	10	3	13	7.92	.10
2.25	8	2	10	6.09	.76
2.50	3	1	4	2.43	.30
2.75	3	3	6	3.65	.46
3.00	2	2	4	2.43	.30
3.50	5	3	8	4.87	.61
4.00	4	1	5	3.04	.38
4.50	8	2	10	6.09	.76
5.00	9	1	10	6.09	.76
5.50	2	2	4	2.43	.30
6.00	5	1	6	3.65	.46
7.00	5	1	6	3.65	.46
8.00	1	1	2	1.21	.15
9.00	0	1	1	.60	.07
10.00	5	0	5	3.04	.38
11.00	1	0	1	.60	.07
12.00	3	0	3	1.82	.23
14.00	1	0	1	.60	.07
	111	53	164	100.00	12.61

Table VIII gives the refraction in dioptrics of 164 myopic eyes. The number of units being very small, I have not attempted to show the results graphically.

Chart E shows the curves for the different forms of astigmatism. The highest percentage is found in compound hyperopic astigmatism (H+Ah.) $45\frac{72}{100}$ per cent; simple myopic astigmatism (Am.) $27\frac{41}{100}$ per cent; compound myopic astigmatism (M+Am.) $12\frac{24}{100}$ per cent; simple hyperopic astigmatism (Ah.) 12 per cent; lastly, mixed, only $2\frac{54}{100}$ per cent.

In conclusion, as the result of my study of these 1,300 cases, I feel that I can do no better than to quote these words from Dr. Gould (a writer from whom I have derived a great deal of inspiration):

"The amount of human misery caused by ocular defects is appalling, and if the prevention and relief of that misery be the motive of scientific medicine, no branch is more important or

demands higher powers of mind than that of ophthalmology, and *nine-tenths of modern ophthalmic practice consists of refraction.*'' *Loc. Cit., p.* 442.

CHART E.